



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/FI92/00063 <b>(22) International Filing Date:</b> 4 March 1992 (04.03.92)  <b>(30) Priority data:</b> 911092                      5 March 1991 (05.03.91)                      FI  <b>(71) Applicant (for all designated States except US):</b> TELENOKIA OY [FI/FI]; Mäkkylän puistotie 1, SF-02600 Espoo (FI).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only) :</b> KANGAS, Sakari [FI/FI]; Nuijapolku 2 A 3, SF-01650 Vantaa (FI).  <b>(74) Agent:</b> OY KOLSTER AB; Stora Robertsgatan 23, P.O. Box 148, SF-00121 Helsinki (FI).		<b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB, GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), MC (European patent), NL (European patent), NO, SE (European patent), US.  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> A CELLULAR RADIO NETWORK, A BASE STATION AND A METHOD FOR CONTROLLING LOCAL TRAFFIC CAPACITY IN THE CELLULAR RADIO NETWORK  <div data-bbox="495 1165 982 1627" data-label="Diagram"> </div>		
<b>(57) Abstract</b>  <p>The invention relates to a method for controlling local traffic capacity in a cellular radio network comprising several base stations (BTS1 - BTS4) each having one or more assigned frequency channels for establishing radio connections with active mobile radios (MS) presently located within a predetermined radio coverage area (CS1 - CS4) thereof, said assigned frequency channels being different at least in base stations having adjoining radio coverage areas. In the invention, at least one of the base stations (BTS1 - BTS3) directs at least one of its assigned frequency channels to another radio coverage area (1 - 3) deviating from the predetermined coverage area (CS1 - CS3) and covering at least partly the radio coverage area of one of the neighbouring base stations (BTS4), when the traffic capacity requirement within the radio coverage area of said neighbouring base station increases substantially.</p>		

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A cellular radio network, a base station and a method for controlling local traffic capacity in the cellular radio network

5     Field of the Invention

          The invention relates generally to a method for controlling local traffic capacity in a cellular radio network comprising several fixed radio stations each having one or more assigned frequency channels for establishing radio connections with active mobile radio stations presently located within a predetermined radio coverage area thereof, said assigned frequency channels being different at least in fixed radio stations having adjoining radio coverage areas.

10     The invention also relates to base stations suitable for use in such a network.

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Background of the Invention

          In cellular mobile radio networks, the geographical area covered by the network is divided into smaller radio coverage areas, i.e. radio cells, each comprising at least one base station. In each cell, a certain number of frequency channels are assigned to the base station, and the frequency channels, in turn, may be time-division multiplexed into several traffic channels on the TDMA principle. Typically, the size and density of the radio cells as well as the number of frequency channels assigned to them are determined by the traffic capacity requirements in each particular area. The cellular mobile radio network may, however, comprise radio cells or larger areas in which the traffic capacity requirements may increase temporarily to a very high degree, e.g. at certain hours of the day. If the number of channels assigned to the radio cell is now determined on the

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basis of this instantaneous maximum capacity, the number of channels will be high, resulting in a higher number of radio equipments at the base station and therefore higher costs. Such an arrangement does  
5 not either enable efficient utilization of radio frequencies in the network. On the other hand, if the number of channels and the base station equipment are not dimensioned on the basis of the peak traffic in a service area, the number of rejected calls will be  
10 very high within that service area at peak hours.

In certain prior art networks, attempts have been made to alleviate the capacity problem by increasing transmitting powers in the network. In GB Patent Specification 1562963, the mobile radios are  
15 able to increase the coverage area (transmitting power) of their transmissions when adjacent base stations are overloaded in order to establish a connection to less loaded, more remote base stations. US Patent Specification 4435840, in turn, teaches a cellular system in which the cell size of an overloaded  
20 base station is temporarily decreased by reducing its transmitting power while correspondingly increasing the transmitting power and the cell size of a neighbouring base station. Changes in transmitting powers may, however, cause interference elsewhere in the  
25 network and complicate the design of the network.

#### Summary of the Invention

The object of the present invention is to  
30 provide an arrangement of a new type for alleviating the capacity problem.

To this end, in a method according to the invention for controlling local traffic capacity in a cellular radio network, at least one of the fixed  
35 radio stations is configured to be capable of tem-

porarily establishing a predetermined additional radio coverage area in addition to a predetermined primary radio coverage area thereof, said additional radio coverage area deviating from the predetermined primary coverage area and covering at least partly a radio coverage area of one of the neighbouring fixed radio stations; and to direct at least one of the assigned frequency channels to said additional radio coverage area when the traffic capacity requirement within the radio coverage area of said one of the neighbouring fixed radio stations increases substantially.

The basic idea of the invention is that the base stations are capable of directing part or all of their capacity (frequency and/or traffic channels) temporarily to the service area of an adjacent radio cell in which the traffic capacity requirement has increased temporarily. When using the invention, the number of channels of an individual radio cell need not be dimensioned by the instantaneous maximum capacity requirements of the particular cell but the dimensioning can be based on the average value of the maximum capacity requirements of several adjoining radio cells. Thus the traffic capacity of an individual cell can be increased, if required, by directing part of the capacity of the neighbouring cells to this cell, thus effectively controlling the local network capacity and improving the utilization efficiency of the equipments and frequency/traffic channels of the base stations. The invention also improves the utilization of radio channels in the entire network.

The invention also relates to a base station realizing the method, comprising at least one radio transmitter and radio receiver and an antenna means

having a predetermined radio coverage area. The base station according to the invention is provided with means for switching at least one radio transmitter between an additional antenna means and said antenna means so as to control the local traffic capacity in the cellular radio network, said additional antenna means having a radio coverage area deviating from said predetermined radio coverage area. In this embodiment of the invention, the antenna connected to the transmitter is changed to redirect a portion of the capacity of the base station.

The invention also relates to a base station for a digital cellular radio system, comprising at least one radio transmitter and radio receiver, an antenna means having a predetermined radio coverage area, and at least one frequency channel assigned to the base station, the frequency channel being divided into several traffic channel time slots on the TDMA principle. In the base station according to the invention, at least one radio transmitter is permanently connected or temporarily connectable to an additional antenna means in addition to said antenna means so that the joined radio coverage area of the two antenna means is variable, in order to control the local traffic capacity of the cellular radio network, between a first radio coverage area substantially corresponding to said predetermined radio coverage area and a second radio coverage area deviating substantially from said predetermined radio coverage area by adjusting the mutual phase difference and/or transmitting power ratio of said two antenna means. In this embodiment, the base station may divide the capacity of the same frequency channel between its own cell and an adjacent radio cell and adjust the division of the capacity into these cells.

The invention further relates to a cellular radio network, comprising several base stations each having one or more assigned frequency channels for establishing radio connections with active mobile radio stations presently located within a predetermined radio coverage area thereof, said assigned frequency channels being different at least in base stations having adjoining radio coverage areas, each base station comprising at least one radio transmitter and radio receiver and an antenna means having said predetermined radio coverage area. In the network according to the invention, at least one base station is provided with means for switching at least one radio transmitter between an additional antenna means and said antenna means in response to the traffic load of one of the adjacent base stations, said additional antenna means having a radio coverage area deviating from said predetermined radio coverage area and covering at least partially the radio coverage area of said one of the adjacent base stations.

#### Brief Description of the Drawings

In the following the invention will be described in greater detail by means of embodiments with reference to the attached drawings, in which

Figure 1 is a diagrammatic presentation of a portion of a cellular mobile radio network in which the method according to the present invention can be applied;

Figure 2 is a block diagram of a transmitter section of a base station according to the invention; and

Figure 3 is a block diagram of a receiver section of a base station according to the invention.

### The Preferred Embodiments of the Invention

The method according to the invention can be applied both in digital mobile radio systems, such as the Pan-European mobile radio system GSM (Groupe Speciale Mobile), and in analog mobile radio systems, such as the Nordic mobile telephone system NMT, for controlling the local traffic capacity in the mobile radio network. As to the basic idea of the invention, the analog and the digital systems are similar, even though one frequency channel forms a single traffic channel in a typical analog mobile radio system whereas the traffic capacity of a typical digital mobile radio system is greater, because several, typically 8, traffic channels are time-division multiplexed for each frequency channel on the TDMA principle, that is, the same frequency channel may have as many as 8 simultaneous connections between the base station and the mobile radios. The basic configuration and basic functions of the GSM and NMT systems are well-known to one skilled in the art and relatively accurately defined in the specifications of the two systems. Certain basic concepts and elements of the mobile radio system (primarily GSM) will be defined below with reference to Figure 1 in so far as they are relevant to the description of the invention. An area within which mobile radio services are available is called a mobile radio network which may cover several countries.

The mobile radio network may comprise one or more service areas, that is, an area within which a single mobile services switching center MSC offers services. The service area may be divided into one or more location areas, that is, an area covered by several radio cells. A cell is the smallest geographical area of the system, comprising one or more fixed



radio stations or base stations BTS and using pre-determined frequency channels.

Figure 1 shows by way of example one service or location area of a cellular mobile radio network, within which the present invention can be applied. The geographical area covered by the cellular mobile radio network is divided into smaller radio areas or radio cells CS1, CS2, CS3 and CS4 substantially continuously so that adjacent radio areas adjoin or overlap. Each radio cell CS1 - CS4 comprises at least one fixed radio station or base station BTS1 - BTS4, respectively, which is capable of establishing a connection with mobile radios MS presently located or moving in the respective radio cell CS1 - CS2 on the assigned frequency channels, that is, at transmitting and receiving frequency pairs (duplex spacing e.g. 45 MHz). Typically, at least neighbouring radio cells have mutually different assigned frequency channels. Each base station BTS further has signalling and traffic channel links with the mobile services switching center MSC, which controls the operation of one or more base stations located in its service area. In the case shown in Figure 1, it is assumed for the sake of simplicity that all base stations BTS1 - BTS4 are connected to the same mobile services switching center MSC.

Figures 2 and 3 illustrate the configuration of a base station according to the invention. Each base station BTS1 - BTS4 within the cellular mobile radio network typically comprises at least one radio transmitter and radio receiver, in the illustrated case two radio transmitters 21 and 22 and two radio receivers 33 and 34, which are all connected to a main antenna unit ANT1. The size and shape of the radio coverage area of the main antenna unit ANT1 determine

the size and shape of the radio cell CS1 - CS4 of each base station BTS1 - BTS4. The main antenna unit ANT1 may comprise separate antennas for transmission and reception.

5           In the transmitter section of the base station the radio transmitter 21 is connected directly to a combiner 24. The other radio transmitter 22 is connected to a controllable change-over switch 23 which connects the radio transmitter 22 to the combiner 24  
10           in its one switching position and to an additional antenna unit ANT2 in its other switching position. The combiner 24 combines the radio-frequency transmitting signals of the radio transmitters 21 and 22 and applies the combined signal to the main antenna  
15           unit ANT1. For the normal operation of the base station, the radio transmitter 22 is connected to the main antenna unit ANT1 through the change-over switch 23 and the combiner 24, so that all the frequency  
20           channels of the base station are within the radio coverage area of the main antenna unit ANT1, that is, available to mobile radios located in the radio cell of the base station.

          In the receiver section of the base station, the main antenna unit ANT1 and the additional antenna  
25           unit ANT2 are connected through a combiner 31 to a distribution amplifier unit 32 which distributes the sum signal of the antenna units to all radio receivers 33 and 34. In the preferred embodiment of the invention, all of the radio receivers are thus  
30           connected permanently to both antenna units ANT1 and ANT2.

          As mentioned above, each base station BTS uses only the main antenna unit ANT1 and communicates only with mobile radios located within its radio coverage  
35           area during normal operation. However, the traffic in

the radio cell CS1, for instance, may increase temporarily so that it is greater than what the base station BTS4 of the cell can handle, while some or all of the neighbouring cells CS1 - CS2 have excess traffic capacity. In such a case at least one of the base stations BTS1 - BTS3 of the neighbouring cells CS1 - CS3 directs part of its assigned frequency channels to another radio coverage area 1, 2 or 3 deviating from the radio coverage area CS1, CS2 or CS3 of the main antenna unit ANT1 and at least partly covering the normal radio coverage area CS4 of the overloaded base station BTS4. As a consequence, the mobile radios MS in the radio cell CS4 may temporarily establish a connection through the neighbouring base station of at least one neighbouring cell. In this way the mobile radio network is able to effectively adjust its capacity and direct excess capacity to overloaded radio cells.

The above-mentioned alternative radio coverage area 1, 2 or 3 is accomplished by means of the additional antenna unit ANT2 positioned in the base station BTS. When part of the frequency channels of the base station are to be directed temporarily to the area of the neighbouring base station, the change-over switch 23 disconnects the radio transmitter 22 from the main antenna unit ANT1 and connects it to the additional antenna unit ANT2.

In an alternative embodiment of the invention, all the transmitters of the base station can be connected to the additional antenna unit ANT2. This is necessary especially in base stations comprising a single transmitter.

In the preferred embodiment of the invention, the change-over switch 23 is controlled by a control signal SC obtained from the mobile services switching

center MSC. For the control of the change-over switch, the mobile services switching center MSC may comprise means for measuring and/or predicting the traffic load of a certain neighbouring base station and for causing the change-over switch 23 to connect the radio transmitter 22 to the additional antenna unit ANT2, when the measured or predicted traffic load of the neighbouring base station exceeds a pre-determined level.

10 In another embodiment of the invention, suitable for use e.g. in TDMA systems, at least one radio transmitter may be temporarily connectable or permanently connected simultaneously to both the main antenna unit ANT1 and the additional antenna unit  
15 ANT2. The power of the transmitter is thereby divided between the two antenna units and the frequency channel of the transmitter can be used simultaneously by the radio cell of the base station and an adjacent cell. The relative size of the coverage areas of the  
20 antenna units can be varied by adjusting the ratio of the transmitting powers supplied from the transmitter to the antenna units. The main antenna unit ANT1 and the additional antenna unit ANT2 may also be phased with respect to each other in a predetermined manner  
25 so that they form a phase-controlled antenna in which the shape of the joined radio coverage area of the antenna units can be varied between a first coverage area corresponding to the radio cell and a second coverage area deviating substantially from it and  
30 covering at least partly the adjacent radio cell by adjusting the phase difference between the signals applied to the antenna units. The antenna units ANT1 and ANT2 may thereby be different radiating elements of the same antenna. In these embodiments, the local  
35 capacity of the radio network can be controlled by

adjusting the power and/or phase difference continuously or in a stepwise manner. These embodiments can be realized easily in the base station shown in Figures 2 and 3 by providing the change-over switch  
5 23 with or by replacing it with suitable signal distribution, power control and/or phase adjustment means. The phase and/or power control can also be controlled by the signal SC from the mobile services switching center.

10 The figures and the description related to them are only intended to illustrate the present invention. In their details, the method, base stations and radio network according to the invention may vary within the scope of the attached claims.

## Claims:

1. A method for controlling local traffic capacity in a cellular radio network comprising several  
5 fixed radio stations (BTS1 - BTS4) each having one or more assigned frequency channels for establishing radio connections with active mobile radio stations (MS) presently located within a predetermined radio coverage area (CS1 - CS4) thereof, said assigned frequency channels being different at least in fixed  
10 radio stations having adjoining radio coverage areas, characterized in that at least one of the fixed radio stations (BTS1 - BTS3) is configured to be capable of temporarily establishing a predetermined additional radio coverage area (1 - 3) in  
15 addition to the predetermined primary radio coverage area (CS1 - CS3) thereof, said additional radio coverage area deviating from the predetermined primary coverage area and covering at least partly a  
20 radio coverage area (CS4) of one of the neighbouring fixed radio stations (BTS4); and to direct at least one of the assigned frequency channels to said additional radio coverage area when the traffic capacity requirement within the radio coverage area of said  
25 one of the neighbouring fixed radio stations increases substantially.

2. A base station for a cellular radio system, the base station (BTS1 - BTS3) comprising at least one radio transmitter (21, 22) and radio receiver  
30 (33, 34) and an antenna means (ANT1) having a predetermined radio coverage area (CS1 - CS3), characterized in that the base station is provided with means for switching at least one radio transmitter (22) between an additional antenna means  
35 (ANT2) and said antenna means (ANT1) so as to control

the local traffic capacity in the cellular radio network, said additional antenna means (ANT2) having a radio coverage area (1 - 3) deviating from said predetermined radio coverage area (CS1 - CS3).

5           3. A base station according to claim 2, characterized in that the base station comprises a controllable change-over switching means (23) by means of which at least one radio transmitter (22) is connectable alternatively to said antenna  
10 means (ANT1) or the additional antenna means (ANT2).

          4. A base station for a digital cellular radio system, the base station (BTS1 - BTS3) comprising at least one radio transmitter (21, 22) and radio receiver (33, 34), an antenna means (ANT1) having a  
15 predetermined radio coverage area (CS1 - CS3), and at least one frequency channel assigned to the base station, characterized in that at least one radio transmitter (22) is permanently connected or temporarily connectable to an additional antenna  
20 means (ANT2) in addition to said antenna means (ANT1) so that the joined radio coverage area of the two antenna means is variable, in order to control the local traffic capacity of the cellular radio network, between a first radio coverage area substantially  
25 corresponding to said predetermined radio coverage area (CS1 - CS3) and a radio coverage area (1 - 3) deviating substantially from said predetermined radio coverage area by adjusting the mutual phase difference and/or transmitting power ratio of said two  
30 antenna means.

          5. A base station according to claim 4, characterized in that the antenna means (ANT1) and the additional antenna means (ANT2) are different radiating elements of the same antenna.

6. A base station according to any of the claims 2 to 5, characterized in that all the radio transmitters (33, 34) are connected to both said antenna means (ANT1) and the additional antenna means (ANT2).

7. A cellular radio network comprising several base stations (BTS1 - BTS4) each having one or more assigned frequency channels for establishing radio connections with active mobile radio stations (MS) presently located within a predetermined radio coverage area (CS1 - CS4) thereof, said assigned frequency channels being different at least in base stations having adjoining radio coverage areas, each base station comprising at least one radio transmitter (21, 22) and radio receiver (33, 34) and an antenna means (ANT1) having said predetermined radio coverage area (CS1 - CS4), characterized in that at least one base station is provided with means for switching at least one radio transmitter (22) between an additional antenna means (ANT2) and said antenna means (ANT1) in response to the traffic load of one of the adjacent base stations (BTS4), said additional antenna means (ANT2) having a radio coverage area (1 - 3) deviating from said predetermined radio coverage area (CS1 - CS3) and covering at least partially the radio coverage area (CS4) of said one of the adjacent base stations (BTS4).

8. A cellular radio network according to claim 7, characterized in that the base station comprises a controllable change-over switching means (23) for connecting at least one radio transmitter (22) alternatively to said antenna means (ANT1) or to the additional antenna means (ANT2).

9. A cellular radio network according to claim 8, characterized in that the change-over



switching means (23) is controlled from a mobile services switching center (MSC) associated with the base station, and that the mobile services switching center (MSC) comprises means for measuring and/or  
5 predicting the traffic load of at least said one of the adjacent base stations (BTS4) and for causing the change-over switching means (23) to connect at least one radio transmitter (22) to the additional antenna means (ANT2) when the measured or predicted traffic  
10 load of said one of the adjacent base stations (BTS4) exceeds a predetermined level.

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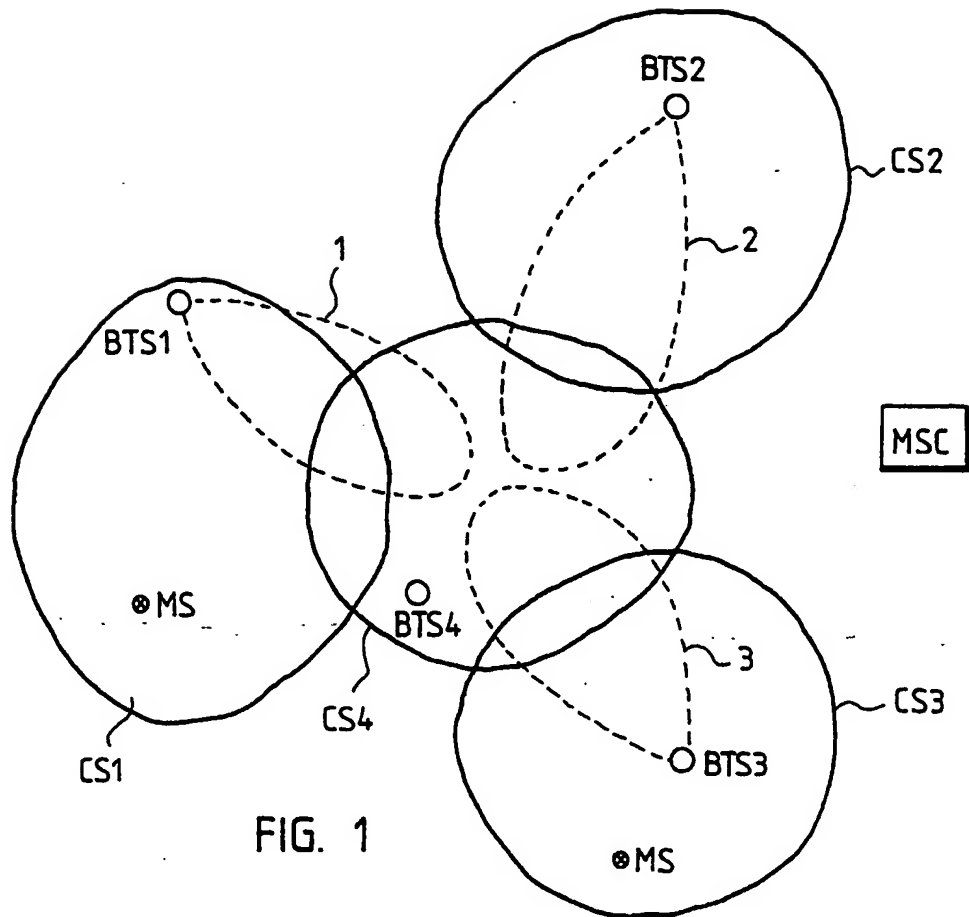


FIG. 1

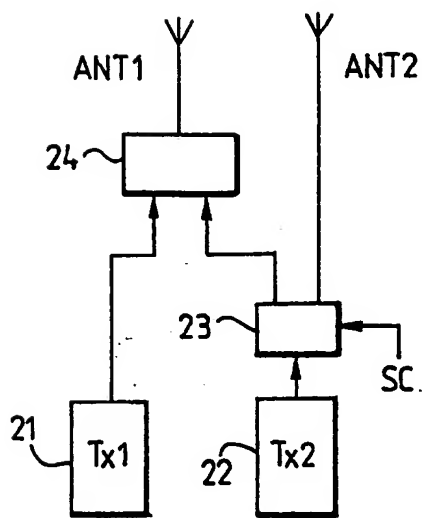


FIG. 2

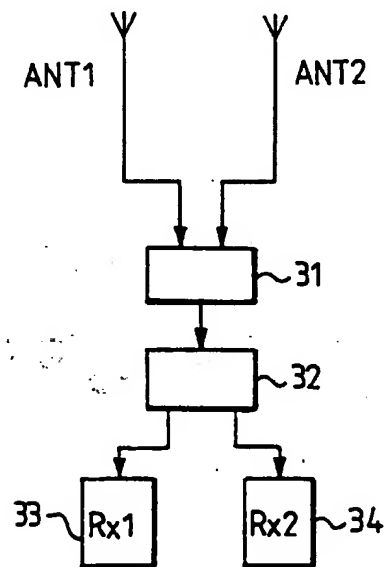
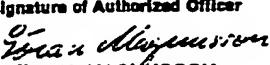


FIG. 3

# INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 92/00063

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC5: H 04 B 7/26, H 04 Q 7/04		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC5	H 04 B, H 04 Q	
Documentation Searched other than Minimum Documentation to the extent that such Documents are included in Fields Searched <sup>8</sup>		
SE,DK,FI,NO classes as above		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>*</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	US, A, 4435840 (JUNICHIROH KOJIMA ET AL) 6 March 1984, see column 4, line 22 - line 58; column 6, line 44 - line 48; figure 1 cited in the application --	1
X	GB, B, 1562963 (SIEMENS AKTIENGESellschaft) 19 March 1980, see page 4, line 39 - line 11; figure 2 cited in the application --	1
X	EP, A1, 0399206 (MOTOROLA, INC.) 28 November 1990, see column 2, line 30 - column 3, line 2 --	2,3
<p><sup>*</sup> Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
17th June 1992	1992-06-18	
International Searching Authority	Signature of Authorized Officer	
SWEDISH PATENT OFFICE	 GÖRAN MAGNUSSON	

## III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
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X,P	EP, A2, 0416872 (MOTOROLA INC.) 13 March 1991, see column 3, line 16 - column 4, line 45; figures 2,4,5 -- -----	1-9
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. PCT/FI 92/00063**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 29/05/92. The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4435840	84-03-06	AU-B- 546036	85-08-08
		AU-D- 8509582	83-01-06
		CA-A- 1176311	84-10-16
		JP-C- 1516439	89-09-07
		JP-A- 58161542	83-09-26
		JP-B- 63065247	88-12-15
		AU-D- 1366283	83-10-27
		GB-A-B- 2125124	84-02-29
		JP-C- 1516441	89-09-07
		JP-A- 58173925	83-10-12
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		JP-A- 57210739	82-12-24
		JP-B- 63029862	88-06-15
GB-B- 1562963	80-03-19	AT-B- 365025	81-12-10
		BE-A- 862543	78-06-30
		CH-A- 625091	81-08-31
		DE-B-C- 2659569	78-05-11
		FR-A-B- 2376571	78-07-28
		JP-C- 1197816	84-03-21
		JP-A- 53084604	78-07-26
		JP-B- 58028975	83-06-20
		NL-A- 7714547	78-07-04
EP-A1- 0399206	90-11-28	AU-D- 5536690	90-12-18
		US-A- 5048116	91-09-10
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